Advanced triaxial interface elements for nonlinear mesoscale modelling of brick-masonry

***Lorenzo Macorini and Bassam A Izzuddin**

Department of Civil and Environmental Engineering, Imperial College London, UK.

* Corresponding and presenting author: l.macorini@imperial.ac.uk

Abstract

The response of unreinforced masonry components up to collapse is very complex, as it is influenced by the anisotropic and quasi-brittle nature of the material. Mesoscale modelling enables accurate response predictions, since intrinsic and damage induced anisotropies are explicitly captured by employing separate descriptions for the different masonry components. The consideration of material nonlinearity for mortar joints is crucial, as they represent preferential locations where cracks develop and propagate. In this respect, zero-thickness nonlinear interfaces have been successfully employed in 2D and 3D representations for mortar joints within FE mesoscale masonry descriptions. Cohesive material models allowing also for the frictional characteristics of the response are usually adopted to represent the development of cracks in mortar joints induced by shear and bending actions. On the other hand, in most previous numerical descriptions compressive failure is modelled by employing a phenomenological representation, without explicitly considering the complex triaxial interactions between units and mortar which characterise the nonlinear response of masonry under high compressive stresses up to collapse. This paper presents an enhanced mesoscale description for brick-masonry utilising advanced nonlinear zero-thickness interface elements for mortar joints with embedded membrane stresses to couple Mode-I opening with stretching deformations in the discontinuity plane. The local kinematics couple Mode-I separation with in-plane normal strains induced by Poisson's effect allowing the simulation of the typical interaction between mortar joints and units, while circumventing the need for a detailed 3D representation of the individual components at a finer scale. The advanced interface element is implemented in a co-rotational framework which efficiently addresses the influence of large rigid body rotations on the relevant local deformations, and enables the effective consideration of geometric nonlinearity which can potentially influence the ultimate out-of-plane response of slender walls. The performance of the proposed mesoscale modelling approach for masonry is assessed in a number of numerical examples including comparisons against results of physical experiments.

Keywords: **unreinforced masonry, nonlinear analysis, mesoscale modelling, zero-thickness interface elements**